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ABSTRACT GLADYS is an array slit spectrometer that has been used extensively on the Wyoming IR Observatory 2.3 m telescope. The emphasis has previously been on obtaining spectra of point sources having unusual spectral counterparts in the IRAS Atlas of Low Resolution Spectra. More recently, the replacement of a section of the digital electronics with higher quality, printed circuitry has eliminated low-level glitching, making possible calibrated, extended source observations. The revised electronics also makes for improvements in the quality of extracted one-dimensional spectra. The Red Rectangle (HD 44179) is just one example of object for which GLADYS is now particularly well suited. The spectrometer's spectral coverage, which extends from wavelengths shortward of 7.5 μm to wavelengths longward of 13.5 μm, is compatible with the range of useful transmission from the Jelm Mountain site. This spectral region encompasses the peak of the 7.7 μm unidentified emission feature and the continuum longward of the 13 μm emission features seen in the spectra of several long period variable stars (e.g., S Draconis, RX Bootis).

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7.5 to 13.5 μm Spectral Imaging with an Array Spectrometer

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ABSTRACT GLADYS is an array slit spectrometer that has been used extensively on the Wyoming IR Observatory 2.3 m telescope. The emphasis has previously been on obtaining spectra of point sources having unusual spectral counterparts in the IRAS Atlas of Low Resolution Spectra. More recently, the replacement of a section of the digital electronics with higher quality, printed circuitry has eliminated low-level glitching, making possible calibrated, extended source observations. The revised electronics also makes for improvements in the quality of extracted one-dimensional spectra. The Red Rectangle (HD 44179) is just one example of object for which GLADYS is now particularly well suited. The spectrometer's spectral coverage, which extends from wavelengths shortward of 7.5 μm to wavelengths longward of 13.5 μm, is compatible with the range of useful transmission from the Jelm Mountain site. This spectral region encompasses the peak of the 7.7 μm unidentified emission feature and the continuum longward of the 13 μm emission features seen in the spectra of several long period variable stars (e.g., S Draconis, RX Bootis).

THE GLADYS LONG SLIT SPECTROMETER

The heart of Gladys is a 58x62 pixel mosaic detector array, consisting of Si:Ga detector material hybridized to a 3596:2 multiplexer. The signals of adjacent pixel pairs on a 62 pixel row are output simultaneously over two parallel output conductors. Each of the 1798 address codes remains active during a 4 μsec time interval, during which the signals are clamped, reset, and sampled in the delta-reset mode. The clamp and sample signal processing is done by two channels of warm electronics mounted on the dewar.

Th(12 bit digitized delta-reset signals are electronically coadded in circuitry consisting of RAM and Arithmetic Logic Units. A total of 7192, 20 bit RAM cells are resident so that each pixel may have its source and sky signals coadded into separate cells over several cycles of secondary mirror chopping. An approximate 0.2 sec interval is sufficient to transfer the difference of the source and sky signals over 16 bits of optical isolator interface to the observatory computer.

It will be helpful in the following to name the frames obtained during three levels of coaddition. We denote as "basic" those frames read from the chip into coadder memory, and define "frames" as those coadded electronically and transferred to the computer, and reserve the word "image" for the averages of frames written to disk memory. Table 1 is a listing of the number of "basic" frames electronically coadded for combinations of chop frequency and chop number selected at the front panel of the coadder electronics. This number is not strictly proportional to the chop dwell time, because of the fixed number of frames that is not coadded after each chop transition. The chop delay of 6 frames (CD = 6) corresponds to a time delay of 22 msec and is more than adequate for the secondary mirror to settle after a chop.

TABLE 1: "Basic" Frames Coadded for Coadder Settings

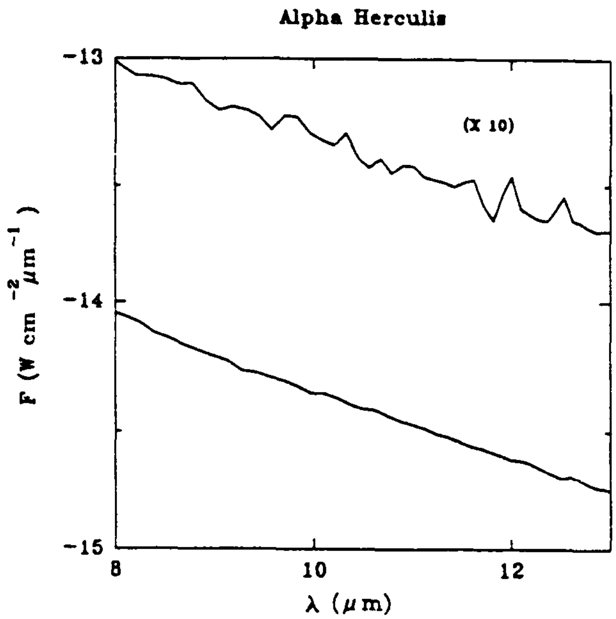
chop setting (CC)	chop pairs	frequency setting (FN) 3	2	1
0	8	465	337	209
3	6	349	253	157
2	4	233	169	105
1	2	117	85	53
Chop dwell time (sec)		0.236	0.176	0.116

The spectrometer optics consists of a modified Czerny-Turner design, uses a NaCl prism as dispersing element, and is operated at liquid Helium temperature. Dispersion increases monotonically from long to short wavelengths. The ratio of focal lengths of the collimator and camera mirrors is equal to 3.6, and results in an f/7.5 focus and 0.9 arcsec pixel^{-1} array plate scale. Slit width is currently 2" and may be changed in the laboratory after removing the bottom lid from the warm dewar.

REVISED ARRAY SPECTROMETER CONFIGURATION

Our published spectra of long period variable stars (LeVan and Sloan 1989, LeVan 1990) were observed using a donated mosaic array of low responsivity; this array corresponded to the manufacturing goal of high pixel uniformity and use for bright targets. Subsequent to collecting the published spectra, we obtained a higher sensitivity array (of responsivity estimated to be 1.5 AW^{-1} at 10 μm with 15 V detector bias). The new array was installed with a corrective shift relative to the spectrometer optics, since a translational misalignment of approximately 0.75 mm between the optics and the original array resulted in a 9 μm cut-on wavelength. The extreme wavelengths at slit positions typically used for point sources are currently 6.8 and 14 μm. Shorter integration times for the higher responsivity array imposed by the sky and telescope thermal background levels were expected. We compensated for this in several ways. By limiting the array "address space" to 10 (and later, 15) rows of 62 pixels each, we shortened the integration time to 1.24 msec, keeping fixed the 250 KHz clocking frequency. We continued to make efficient use of coadder memory by spreading the 10 array rows over 30 coadder rows. The frame is transferred to the computer in this expanded format, and collapsed back to 10 rows in subsequent processing. The reduction of slit length from 53" to 9" permitted spectral imaging of point and mildly extended sources. Also, by decreasing the (warm) load resistance of the on-chip source follower circuitry from 10 to 5 KΩ, and increasing the gate voltage of the "unit cell" source followers from 0.8 to 1.2 V, we improved the signal charge reset speed. The combination of these two approaches have been shown effective in operating the multiplexer at high frequency, for which charging of the signal lead capacitance during reset of the pixel signal is the limiting factor (LeVan and Tandy 1987). Finally, extraneous background signal was significantly reduced upon

Fig 1. Logarithmic fluxes before (top, Jul 1990) and after (bottom, Feb 1991) upgrade of digital coadd circuitry. Each spectrum was reduced by α Boo. The excess noise in the earlier spectrum was apparently the result of low-level digital glitching that affected the brighter star α Her and the standard α Boo by roughly equal amounts.

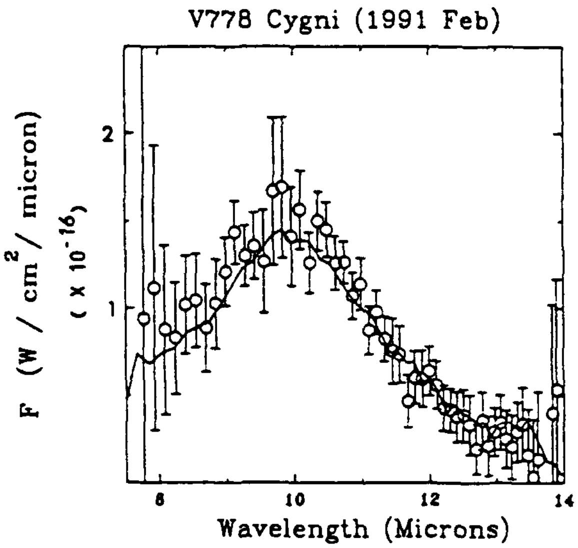


installation of a radiation baffle which extends from the radiation shield to just short of the dewar entrance window.

COADDER GLITCHING

The most recent upgrading of Gladys replaced wired circuit boards with printed circuit versions. The revised circuitry had been built originally to correct a digital supply voltage instability, but shortly afterwards it became apparent that images of Jupiter could not be flat fielded with the original circuitry. The revised circuitry rectified the flat fielding difficulties found for images of Jupiter, and also dramatically improved the quality of extracted point source spectra. In retrospect, it appears that low level glitching during the electronic coadds, of amplitude probably related to the source signal level, was affecting our ability to flat field. Figure 1 shows spectra of α Herculis reduced with images of α Bootis, before and after the circuitry upgrade. In this typical example, it is apparent that we now can obtain clean spectra for high S/N observations. Smooth spectra of high S/N sources could be obtained prior to the electronics upgrade only by deriving the atmospheric correction from one such bright source, rather than from the fainter standard stars now employed. The absolute flux levels appear unaffected, but the variability of α Her and non-photometric nature of a slit spectrometer limit comparison to the 10% level. Figure 2 shows a lower S/N spectrum extracted from images obtained with the upgraded coadder circuitry.

Fig 2. Gladys spectrum (shown with error bars) of one of several examples of carbon star having an IRAS silicate emission feature spectrum (solid line; scaled upward by the factor 1.2). The Gladys spectrum was extracted from 10 images of 40 frames each (approx. 25 min integration time).



DATA ACQUISITION SOFTWARE

A menu-driven data acquisition software package has been written for Gladys in the C programming language by a Wyoming IR Observatory graduate student (Greg Sloan). Two illustrative menu selections are now described. Array flat fields are acquired in the "stare" data acquisition mode for which the specified number of frames transferred from Gladys are averaged. In the "3 beam chop" mode, the secondary mirror chopping waveform toggles from source to sky alternately to the north and south of the source (Landau, Grasdalen, and Sloan 1991). In the 3 beam chop data acquisition mode, source and sky signals are exchanged in their usual coadder RAM blocks on alternating "frames". Differences of pairs of such frames lead to positive source signals and reduction of array "fixed pattern" noise. The Gladys software incorporates an "intelligent interface" whereby the sequence of menu prompts reflects prior selections. The range of the false color data display is either determined automatically or taken from values specified in the menu. A video display program is useful for peaking on objects and making focus adjustments. The video program displays images as they are acquired without saving them to disk memory, and recognizes parameter values defined in the menu. The data acquisition program provides a root data file name and numerical suffix for the FITS images written to disk. The suffix increments automatically unless the operator chooses not to save the most recent image.

PLANS FOR THE FUTURE

We are investigating the possibility of a further increase in the number of array rows read along the spatial axis from the current value of 15. This would provide coverage over a larger angular extent on the sky and also make for an increase in pixel integration time. Longer pixel integration times will allow for lower amplifier gains and may lead to an increase in sensitivity. Also, a user's manual for GLADYS is in preparation.

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